



# National Institute of Standards & Technology

## Certificate

### Standard Reference Material<sup>®</sup> 762

#### Magnetic Moment Standard - Nickel Disk

This Standard Reference Material (SRM) is intended for use in the calibration of magnetometers (such as vibrating sample magnetometers) used in the measurement of the magnetic properties of materials. SRM 762 consists of a nickel disk nominally 6 mm in diameter with a thickness of 0.127 mm and a mass of 32 mg  $\pm$  1 mg. The SRM 762 lot was produced from rolled nickel sheet with a purity of 99.999 %. Disks were punched from the sheet. Before measurement, the disks were ultrasonically cleaned in acetone, then methyl alcohol.

**Certified Value and Uncertainty:** The certified value for specific magnetization,  $\sigma$  at 298 K and in an applied magnetic field of 398 kA/m (5000 oersted, Oe) with the magnetic field aligned parallel to the plane of the disk is:

$$\sigma = 54.78 \text{ A}\cdot\text{m}^2/\text{kg} \pm 0.15 \text{ A}\cdot\text{m}^2/\text{kg} \text{ (54.78 emu/g} \pm 0.15 \text{ emu/g)}$$

The uncertainty in the certified value is calculated as  $U = ku_c$ , where  $k = 2$  is the coverage factor for a 95 % level of confidence, and  $u_c$  is the combined standard uncertainty calculated according to the NIST policy [1-3].

Corrections for temperature and field can be made using equation 1:

$$\sigma = 54.78 \left[ 1 + 0.0051 \ln\left(\frac{H}{398}\right) \right] \left[ 1 - 0.00053(T - 298) \right] \quad (1)$$

where  $\sigma$  is the specific magnetization in  $\text{A}\cdot\text{m}^2/\text{kg}$ ,  $H$  is the applied magnetic field strength in kA/m, and  $T$  is the thermodynamic temperature in kelvins. These corrections have no significant effect on the uncertainties for temperatures between 293 K and 303 K and for fields between 318 kA/m and 478 kA/m (4000 Oe and 6000 Oe). For an extended range,  $H$  between 280 kA/m and 4000 kA/m (3500 Oe and 50 000 Oe) and  $T$  between 280 K and 310 K, the uncertainties are approximately doubled. To modify Equation 1 for  $\sigma$  in emu/g and  $H$  in Oe, replace the value 398 with 5000. To determine the magnetic moment,  $m$ , in  $\text{A}\cdot\text{m}^2$ , multiply the specific magnetization in  $\text{A}\cdot\text{m}^2/\text{kg}$  determined from equation (1) by the mass in kg as measured by the user.

**Expiration of Certification:** The certification of this SRM is valid indefinitely within the measurement uncertainties specified, provided the SRM is used in accordance with the instructions in this certificate. If deformation or discoloration of the nickel disk are visible, discard the unit.

Certification of this SRM was performed by R.D. Shull, R.D. McMichael, and L.J. Swartzendruber of the NIST Metallurgy Division.

Statistical analysis and measurement advice were provided by S.D. Leigh of the NIST Statistical Engineering Division.

The support aspects involved in the preparation, certification, and issuance of this SRM were coordinated through the NIST Standard Reference Materials Program by R.J. Gettings.

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SRM 762

J.G.Hodos, and R.V. Drew of the NIST Metallurgy Division, H.E. Metger of the NIST Fabrication Technology Division, and G.A. Candela, retired.

**Instructions for Use:** Before use, the user should accurately determine the mass of the nickel disk to within 0.1 mg or better. The disk should be carefully cleaned, dried, and all dust removed before the mass determination.

**Measurement Technique:** The magnetic moment was determined by a sampling technique using an absolute magnetometer developed at NIST based on the Faraday method. The magnetometer was calibrated using three different methods to determine the value of the field gradient. The specific magnetization,  $\sigma$ , was determined by dividing the magnetic moment value by the mass. The same magnetometer used in the certification of SRM 772a was employed in the certification of this SRM. However, the value obtained for  $\sigma$  of this lot of nickel disks differs slightly from that obtained from the SRM 772a lot of nickel spheres due to differences in thermo-mechanical treatment between the two SRMs.

**Storage and Handling:** To avoid accidental loss of the nickel disk, the SRM 762 box should be held on a level surface while opening. When not in use, the SRM should be stored in the box provided or in a manner that provides equivalent or better protection against loss or damage. The nickel disk should be carefully handled to avoid scratching, deformation, or the attachment of magnetic dust or particles from the environment. The use of plastic or other non-magnetic tweezers with smooth surfaces and a gentle grip is recommended. Do not expose the SRM to corrosive chemicals or heat in an oxidizing atmosphere.

**NOTE ON UNITS:** One Oe corresponds to  $(1000/4\pi)\text{A/m}$ . For additional discussion on units of measure, refer to References 4 and 5.

#### REFERENCES

- [1] *Guide to the Expression of Uncertainty in Measurement*, ISBN 92-67-10188-9, 1st Ed., ISO, Geneva, Switzerland, (1993); see also Taylor, B.N. and Kuyatt, C.E., "Guidelines for Evaluating and Expressing the Uncertainty of NIST Measurement Results," NIST Technical Note 1297, U.S. Government Printing Office, Washington DC, (1994); (available at <http://physics.nist.gov/Pubs/>).
- [2] "U.S. Guide to the Expression of Uncertainty in Measurement," ANSI/NCSL Z 540-2-1997, National Conference of Standards Laboratories, Boulder, CO, (1997/1998).
- [3] Rukhin, A.L. and Vangel, M.G., "Estimation of a Common Mean and Weighted Means Statistics," *Journal of the American Statistical Association*, **93** #441, pp. 303-308, (1998).
- [4] Bennett, L.H., Page, C.H., and Swartzendruber, L.J., "Comments on Units of Magnetism," *J. Res. Nat. Bur. Std.*, **83(1)**, p. 9, (1978).
- [5] Taylor, B.N., "Guide for the Use of the International System of Units (SI)," NIST Special Publication 811, April 1995.

*Users of this SRM should ensure that the certificate in their possession is current. This can be accomplished by contacting the SRM Program at: Telephone (301) 975-6776 (select "Certificates"), Fax (301) 926-4751, e-mail [srminfo@nist.gov](mailto:srminfo@nist.gov), or via the Internet <http://ts.nist.gov/srm>.*